NAME: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ Chemistry 313

Chapter 12

**CHEMICAL QUANTITIES**

***Chapter Outline***

12.2 🡪 Using Moles

*Vocabulary*

|  |  |  |
| --- | --- | --- |
| Molar Volume | Ideal Gas Law | Empirical Formula |
|  |  |  |

*Objectives*

* **Predict** quantities of reactants and products in chemical reactions
* **Determine** mole ratios from formulas for compounds.
* **Identify** formulas of compounds by using mass ratios

|  |  |
| --- | --- |
| **Term** | **Definition** |
| Molar Volume | The volume that a mole of gas occupies at STP, |
| Ideal Gas Law | PV=nRT, used when STP conditions do not exist |
| Empirical Formula | Lowest whole-number ratio of atoms in a compound |

Warm-up

**Slide 3: What is Stoichiometry**

Stoichiometry is the study of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_relationships between amounts of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ used and \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ formed by a chemical reaction.

A \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is needed to solve any stoichiometry problem.

**Slide 4: Practical Applications of Stoichiometry**

In a spacecraft, the carbon dioxide exhaled by astronauts can be removed by its reaction with lithium hydroxide, LiOH, according to the following chemical equation.

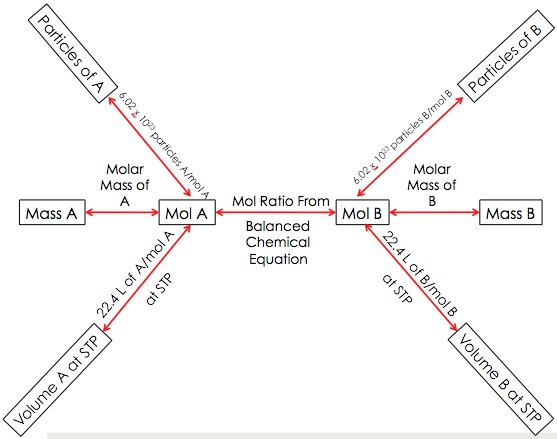
\_\_CO2(g) + \_\_LiOH(s) \_\_ Li2CO3(s) +\_\_ H2O(l)

How many moles of lithium hydroxide are required to react with 20 mol of CO2, the average amount exhaled by a person each day?

Answer: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Slide 5: Strategy – Relate everything to the mole**

The \_\_\_\_\_\_\_\_\_\_ is the common thread that links reactants to products.

[](http://www.google.com/url?sa=i&rct=j&q=stoichiometry+mole+map&source=images&cd=&cad=rja&docid=2XsqxpwvxNCqQM&tbnid=hAJdv9S5r4CjhM:&ved=0CAUQjRw&url=http://moodleshare.org/mod/page/view.php?id=8673&ei=i_iGUYDmDJPH0AGhvYGoBQ&bvm=bv.45960087,d.dmQ&psig=AFQjCNHrP92TGsfdtBNzHo7hFqmIODpCyQ&ust=1367886300184711)**Slide 6: The Mole Super Highway**

**Slide 7: Practice Problems – Mole to Mole**

How many moles of water are formed when 3.8 moles of Hydrogen react with an excess of Oxygen?

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

How many moles of oxygen are needed to fully combust 1.6 moles of ethane(C2H6)?



Warm-up

**Slide 9: Practice Problems – Mole to Mass**

How many grams of water are formed when 4.5 moles of oxygen react with an excess of hydrogen?

How many moles of oxygen are needed to produce 15.6g of carbon dioxide?



**Slide 10: Practice Problems – Mass to Mass**

How many grams of water are formed when 18.6 grams of oxygen react with an excess of hydrogen?

How many grams of ethane are needed to produce 23.4g of water?

Warm-up

**Slide 12: Practice Problems – Volume at STP**

How many liters of oxygen are required to react with 5.6 liters of hydrogen to produce water at STP?

**Slide 13: Solving forVolume without STP Conditions**

* When a chemical reaction is carried out under conditions other than STP, the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_ equation must be used.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ is the Ideal Gas Law Equation where….

* P = pressure
* V = volume
* n = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
* R = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ = =
* T = temperature in \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Slide 14: Practice Problems – Ideal Gas Law**

PV=nRT R = gas constant = =



What volume of carbon dioxide can be produced from 1.2 moles of ethane gas at 200K and 0.65 atm?

Warm-up

**Slide 16: Percent Yield**

Stoichiometric calculations provide a theoretical yield or maximum amount of product that can be produced from a given amount of reactants.

The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ yield is the amount that is actually produced when a reaction is carried out.

The \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ yield reflects the ratio of the theoretical and actual yields



**Slide 17: Practice Problem - Percent Yield**

When 4.3 grams of sodium are combined with aluminum nitrate in the following equation, 1.52g of aluminum are produced. What is the percent yield of aluminum?

Warm-up

**Slide 19: Percent Composition by Mass**

The total mass of each individual \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_in a compound divided by the total mass of the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

What is the percent composition of Mg(BrO4)2?

Remember how to calculate molar mass…..

1(mass Mg) + 2(mass of Br) + 8(mass of oxygen) = Mass of Mg(BrO4)2

Warm-up

**Slide 21: Empirical Formula**

Chemical formula which contains the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_whole number ratio of \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_.

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ formulas always contain the lowest whole number ratios

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ compounds do not always contain the lowest whole number ratios

What is the Empirical Formula of the following compounds?

C3H9O6

C6H12O6

H2O2

**Slide 22: Determining the Empirical Formula of a Compound**

What is the empirical formula for a compound which contains 25.9% nitrogen and 74.1% oxygen by mass?

1. Covert % to mass (if needed)

Assume a 100g sample. In that sample \_\_\_\_\_\_\_\_\_ g is nitrogen and \_\_\_\_\_\_\_\_\_g is oxygen

1. Convert mass to moles
2. Divide each molar quantity by the lowest number of moles
3. Multiply by the smallest number needed to create a whole number ratio (if needed)

Warm-up

**Slide 24: Molecular Formulas**

Many chemicals can have the same \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_l formula because atoms can share \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ in many ways.

Acetic Acid

Glucose

Empirical Formula = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Slide 25: Simple Molecular Problems**

What is the molecular formula of a compound with an empirical formula of CH2O and a molecular mass of 90g/mol?

1. Determine the empirical mass
2. Divide the molecular mass by the empirical mass to determine how much larger the mass of the molecule is compared to the empirical formula
3. Multiple the subscripts of each element in the empirical formula by the factor determined in #2

**Slide 26: Longer Molecular Problems**

1. Determine the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_formula
2. Given the molecular mass, determine the \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ formula

Determine the molecular formula of a compound that has a mass of 34g and contains 94.1% oxygen and 5.9% hydrogen by mass.

Mole-Mole Stoichiometry ( 1 step)

1. How many moles of hydrogen are required to produce 2.45 mole of ammonia?

**\_\_N2 + \_\_H2 → \_\_NH3**

1. How many moles of potassium chloride are produced when 10.03 mole of potassium chlorate decomposes?

**\_\_KClO3 → \_\_KCl + \_\_ O2**

1. How many moles of zinc are required to react with 47.90 moles of hydrochloric acid?

**\_\_Zn + \_\_HCl → \_\_ ZnCl2**

1. How many moles of water vapor are produced when 66.20 moles of oxygen reacts with hexane?

**\_\_C6H14  + \_\_O2 → \_\_CO2 + \_\_H2O**

1. How many moles of potassium bromide are required to produce 80.035 moles of aluminum bromide?

**\_\_Al(NO3)3 + \_\_ KBr → \_\_AlBr3 + \_\_KNO3**

Mole – Mass Stoichiometry (2 steps)

1. How many grams of ammonia are produced when 7.40 mole of hydrogen react with nitrogen?
2. How many grams of potassium chlorate will decompose to form 25.9 mole of oxygen gas?
3. How many moles of zinc chloride are formed when 3.61 g of hydrochloric acid reacts?
4. How many moles of hexane are needed to produce 45.8 g of carbon dioxide?
5. How many grams of aluminum nitrate are required to produce 11.9 moles of potassium nitrate?

**Masss – Mass Stoichiometry (3 steps)**

* 1. How many grams of ammonia are produced if 9.50 g of nitrogen are available?
  2. How many grams of potassium chlorate are required to produce 20.07 grams of potassium chloride?
  3. How many grams of hydrochloric acid are required to produce 15.5 grams of zinc chloride?
  4. How many grams of water will be produced if 10.0 grams of oxygen are available?
  5. How many grams of aluminum nitrate are needed to produce 40.77 grams of aluminum bromide?

**Stoichiometry Worksheet 4 (Mass-Volume/Volume-Volume at STP**

1. Pentane (C5H12) burns according to the following *unbalanced* reaction: Assume STP

\_\_\_\_C5H12 (g) + \_\_\_\_O2 (g) \_\_\_\_CO2 (g) + \_\_\_\_H2­O(g)

1. What volume of O2 is required to produce 48.0 L of Carbon dioxide?
2. What volume of H2O(g) is produced when 106 L of CO2 is created?
3. What mass of Pentane would be required to produce 80.0 L of CO2?

2. Given the following equation:

3 NO2 (g) + H2O(l) 2 HNO3 (aq) + NO(g) Assume STP

1. If 42.0 L of NO(g) is produced, what volume of NO2 (g) reacted?
2. What volume of Nitrogen monoxide would be produced from 100.0 g of water?

2. The corrosion (rusting) of iron is represented as follows:

3 O2­ (g) + 4 Fe(s) 2 Fe2O3 (s)

1. What volume of Oxygen gas would be required to produce 16.0 g of Fe2O3 at STP?

**Gas Stoichiometry Practice - Solutions**

*For all of these problems, assume that the reactions are being performed at a pressure of 1.0 atm and a temperature of 298 K.*

1) Calcium carbonate decomposes at high temperatures to form carbon dioxide and calcium oxide:

**CaCO3(s) 🡪 CO2(g) + CaO(s)**

How many grams of calcium carbonate will I need to form 3.45 liters of carbon dioxide?

2) Ethylene burns in oxygen to form carbon dioxide and water vapor:

**C2H4(g) + 3 O2(g) 🡪 2 CO2(g) + 2 H2O(g)**

How many liters of water can be formed if 1.25 liters of ethylene are consumed in this reaction?

3) When chlorine is added to acetylene, 1,1,2,2-tetrachloroethane is formed:

**2 Cl2(g) + C2H2(g) 🡪 C2H2Cl4(l)**

How many liters of chlorine will be needed to make 75.0 grams of C2H2Cl4?

**Percent Composition Worksheet**

1. What is the percent composition of nitrogen in AgNO3?
2. What is the percent composition of carbon in C2H5O?
3. What is the percent composition of hydrogen in H2SO4?
4. What is the percent composition of sulfur in sulfur hexafluoride?
5. What is the percent composition of iron in iron (II) sulfide?
6. What is the percent composition of lithium in lithium phosphate?

**Empirical and Molecular Formula Worksheet**

Write the empirical formula for the following compounds.

1) C6H6

2) C8H18

3) WO2

4) C2H6O2

5) X39Y13

1. If a compound is 85.70% Carbon and 14.30% Hydrogen. What is the empirical formula of the compound?
2. Elemental analysis reveals that a certain compound is made up of 26.57% K, 35.36 % Cr, and 38.07 % O. Find the empirical formula.
3. A compound contain 20.11 % H, and 79.89% C. Find:
4. The empirical formula
5. The molecular formula, if the molecular mass is 30 g.
6. A compound contains 40.0% Carbon, 6.73% Hydrogen, and 53.3% Oxygen. Find:
7. Empirical Formula
8. Empirical Mass
9. Molecular Formula, if the Molecular mass is 181 g.
10. A compound consists of 19.30 % Na, 26.91 % S, and 53.80 % O. Find:
11. The empirical formula
12. The molecular formula, if the molecular mass is 237.9 g.